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The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by

LEON CASTER

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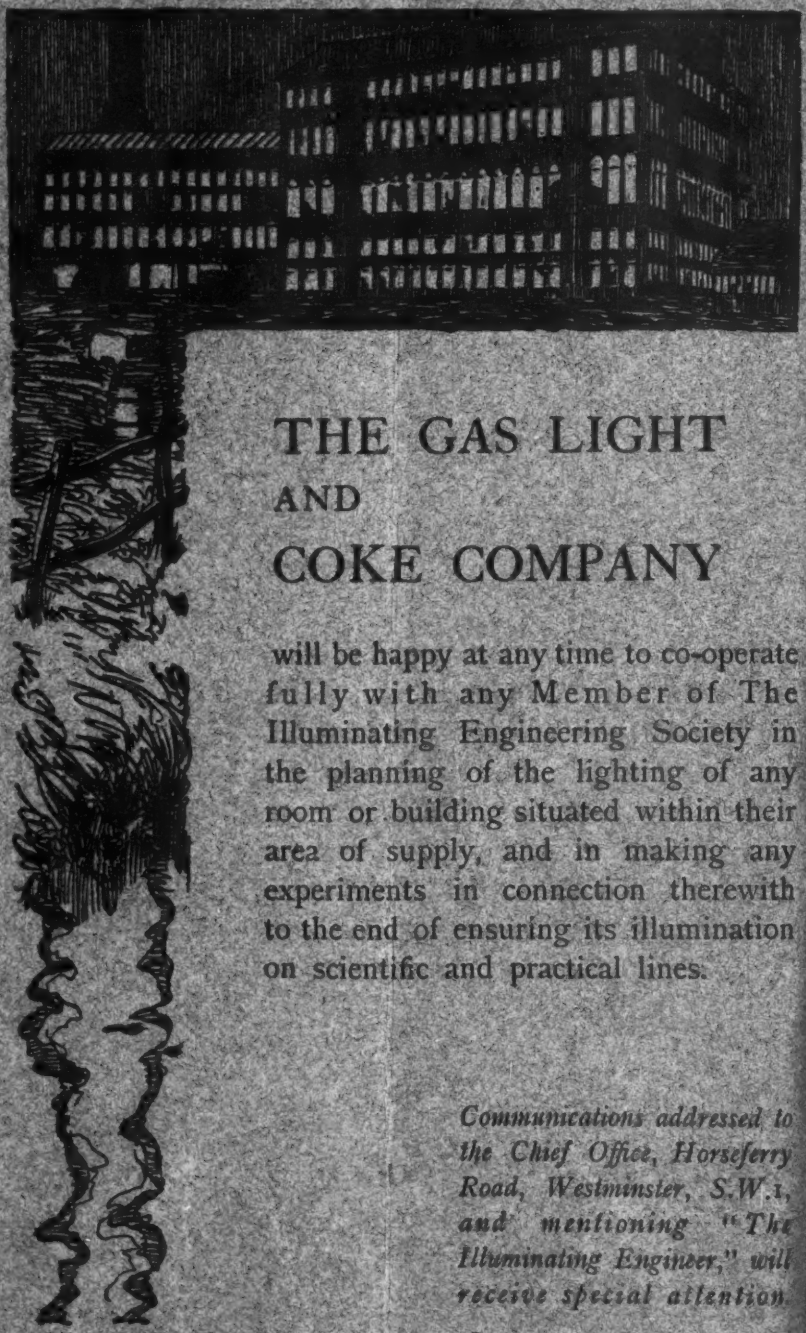
This number contains the Discussion on **"The Need for Suitable Training in Illuminating Engineering,"** opened by MR. C. E. GREENSLADE and MR. J. E. S. WHITE at the Meeting of The Illuminating Engineering Society on January 16th, 1923.

Other matters dealt with include :—

THE NATIONAL ILLUMINATION COMMITTEE (CHAIRMAN'S REPORT FOR 1922 AND LIST OF PHOTOMETRIC DEFINITIONS)—LIGHTING CONDITIONS IN MINES—THE NEW RESEARCH LABORATORIES OF THE GENERAL ELECTRIC CO., LTD., Etc.



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EDITORIAL.

Education in Illuminating Engineering.

The question of the training of the illuminating engineer, and the fields of knowledge to be studied by those concerned with all forms of lighting problems, formed the subject of comment in Professor Silvanus P. Thompson's inaugural address before the Illuminating Engineering Society in 1909, and it has been constantly before us in subsequent years. Professor Thompson himself was, by universal consent, esteemed as one of the most able teachers and lecturers of his day and was responsible for a great deal of educational work in illuminating engineering, both among his own students and in the scientific and popular lectures for which he was famous. In subsequent years numerous efforts to arrange lectures on illuminating engineering were made, and in 1912 courses were conducted at three of the chief technical institutes in London, the individual lectures being delivered by members of the Society who were experts in their respective subjects. In later years several educational institutions which include among their staff members of the Illuminating Engineering Society have developed courses of their own, and there have been several very complete post-graduate courses arranged by the Illuminating Engineering Society in the United States, notably the series of lectures at the Johns Hopkins University, Baltimore, in 1910, and the similar series at the Pennsylvania University in 1916.

There has been abundant evidence recently of the growing interest in lighting matters and the need for better facilities for instruction in the subject. The paper on " The Need for Suitable Training in Illuminating Engineering " read by Mr. C. E. Greenslade and Mr. J. E. S. White before the Illuminating Engineering Society on January 16th was therefore timely. As a preliminary to this discussion a list of queries (see p. 34) was circulated amongst professors at leading colleges and technical institutes. The replies so far received have been encouraging as showing that at a number of institutions some facilities for education in illuminating engineering already exist, though it is generally recognised that much remains to be done and the co-operation of the Society in bringing courses up to date and framing the syllabus is generally welcomed.

The subject, as dealt with in the paper by Messrs. Greenslade and White, falls into several divisions. A considerable amount of educational work is already done by the Society, through their discussions and the valuable publicity given to them in the technical Press. Another educational channel that deserves to be more fully utilised is the arrangement of popular lectures which could be made highly interesting and attractive. It is also desirable that the nature of good lighting should be brought to the notice of young people in secondary schools, so that the next generation may grow up with a proper recognition of its benefits. Instruction of this kind would naturally have to be of a general character, such as would awaken an interest in lighting matters. Dr. F. T. Chapman, of the Board of Education, who opened the discussion, expressed his strong personal sympathy with the aims in the paper, and suggested that occasional addresses to teachers in secondary schools and technical institutes, who in turn would find opportunities of conveying the information to pupils and students, might be arranged with advantage. In some cases outside experts might be engaged to give lectures. The position is now quite different from what it was ten years ago, as available information has become crystallised, and there are now sufficient members of the Society fully qualified to give instruction.

The allowance of time to illuminating engineering doubtless requires some care, and the multiplicity of subjects included in modern curricula is referred to by many of the speakers in the discussion. But in many cases time might be found by excluding less important matters, for instance, by concentrating on the applications of light rather than details of manufacture of lamps, mantles and accessories, with which few students will be concerned in later life. Ultimately, no doubt, arrangements may be made for post-graduate courses in illuminating engineering, for those who wish to devote themselves specially to this subject.

Many sympathetic and useful suggestions were made by Dr. Chapman, Professor French of Leeds University, Dr. L. C. Martin of the Imperial College of Science and Technology, and others associated with technical colleges who joined in the discussion. Arrangements are now being made for the formation of a small joint committee, on which the Society and educational bodies would be represented, to put these ideas in practical shape. One other point that was strongly emphasised was the need for a suitable textbook on illumination for the use of teachers and students. This question will also be considered by the Committee, and preliminary arrangements with a view to meeting the cost of publication are already being made.

The Lighting of Schools and Colleges.

In connection with the discussion before the Illuminating Engineering Society on " The Need for Suitable Training in Illuminating Engineering," it seems advisable to say a few words on the lighting of schools and colleges. In educational institutions where instruction in illuminating engineering is given the lighting of the building should be thoroughly up to date. The student should not feel that the principles advocated in lectures are ignored in the lighting of the classrooms.

The whole question of the lighting of schools and colleges was very fully discussed before the Illuminating Engineering Society in 1911, and the chief principles were summarised in the report of the Joint Committee issued in 1913. Essentially these apply equally well to-day, but our facilities in the form of lamps and fittings are better, and it is probable that the order of illumination then advocated (two foot-candles *minimum*) might now be exceeded with advantage.

Some instructive evidence of recent progress is afforded by a recent paper by Professor H. B. Dates before the Illuminating Engineering Society in the United States. The paper gives the results of a survey of 123 school installations, undertaken at the request of the Cleveland School Board, and contains in an appendix a detailed specification of the lighting fittings. Enclosing globes of diffusing glass were adopted, partly with a view to avoiding troubles due to collection of dust in open bowls. The dimensions of globes were also specified with a view to limiting the brightness and avoiding glare. A table shows average illuminations in different rooms ranging from 2·1 to 3·7 foot-candles. In the discussion it was considered that the values of illumination were somewhat low, and Mr. J. A. Hoeveler stated that in Wisconsin a minimum of five foot-candles was now being required, while in some recent installations up to 10 foot-candles has been provided.

In this country much attention has been given to the lighting of the L.C.C. schools, and good results have been obtained in many cases by replacing obsolete upright gas burners by those of the latest superheated inverted type. It is interesting to observe that when, on February 7th, the question of conversion to electric lighting arose, a proposal was made that the Education Committee should consult with the Illuminating Engineering Society and the Institution of Electrical Engineers and get the benefit of their advice. We need not say that the assistance of the Society will be readily forthcoming on any future occasion when the method of lighting in L.C.C. schools is under consideration.

There are many other questions, in addition to the use of illuminants for lighting classrooms, that deserve study, notably the choice of colours for walls, both in relation to artificial lighting and with a view to promoting good diffusion of daylight. In addition, there are opportunities for the skill of the illuminating engineers in such special problems as the projection of light in the optical and kinema lanterns, the illumination of the fields of microscopes, etc.

The Effect of Light on Eyesight.

In this journal attention has constantly been devoted to the effect of light on the eye, and the very first issue contained a section devoted to this subject.* Little justification is needed for emphasising the application of light in such a manner as to promote comfortable vision—for instance, by the avoidance of glare from direct sunlight and the proper shading of modern light sources, the intrinsic brilliancy of which so greatly exceeds those used in days gone by. We have therefore frequently advocated the collection of data showing by actual experience the effects of unsuitable lighting on the eye. But while it is generally conceded that such evils as excessive glare and insufficiency of illumination are bound to have a prejudicial effect on vision, the problem of collecting convincing evidence on this point is complicated by many other factors. We must, for example, bear in mind the self-protection afforded by the powers of adaptation of the eye, as illustrated in the eyes of races who habitually dwell in snowy regions or in the glare of the desert.

For this reason we consider that scrupulous care should be exercised in drawing conclusions on this question, and it is most undesirable that the matter should be confused by the issue of alarmist statements, unsupported by evidence such as scientific men can accept. From time to time injudicious and extreme views are apt to find expression in the Press, and these only hamper the efforts of genuine investigators who are seeking to promote a better general appreciation of the benefits of scientific methods of illumination. A typical case was afforded by the paper read by Mr. A. E. Bawtree before the Royal Photographic Society on February 13th. The author's contention that there has been a great increase in eye trouble during recent years, and that this is to be ascribed solely to the use of modern illuminants in preference to the less efficient but less brilliant sources of the past, was not supported by evidence. While it is freely admitted that modern sources require proper screening, and we have for many years emphasised this fact, no one can seriously propose for many practical purposes a return to oil lamps and candles and the relinquishing of all the advantages secured by the use of modern electric lamps or incandescent gas mantles. The effects of ultra-violet light, to which the author also attached great importance, have been very fully investigated, and so far as present knowledge goes there seems no reason for believing that they constitute a source of danger in the case of any of the illuminants in general use for ordinary lighting, provided they are used with reasonable discretion. There is evidence that ultra-violet light, while injurious in excess, is beneficial when wisely utilised, a fact that was illustrated in Lord Knutsford's recent account of its use at the London Hospital for the curation of lupus and other diseases. Other problematical dangers, such as X-rays, "induced currents in the optic nerves," etc., mentioned by Mr. Bawtree can safely be disregarded until we have some convincing evidence of these phenomena.

The writer and other members of the Illuminating Engineering Society were present by invitation and took part in the discussion, and other speakers joined in expressing dissent from the extreme views of the lecturer. While it is right that the effects of light on vision should be the subject of scientific study, the investigation is a very complex one, and conclusions should only be formed with great care.

LEON GASTER.

* Jan. 1908, pp. 58–70.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

THE NEED FOR SUITABLE TRAINING IN ILLUMINATING ENGINEERING.

(Proceedings at the meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W.C., at 8 p.m., on Tuesday, January 16th, 1923.)

A MEETING of the Society took place at the House of the Royal Society of Arts (18, John Street, Adelphi, W.C.), on Tuesday, January 16th, the chair being taken by Dr. James Kerr.

The Minutes of the last meeting having been taken as read the HON. SECRETARY read out the names of the following applicants for membership:—

W. M. HAMPTON	Research Chemist, Messrs. Chance Bros. and Co., Glass Works, Smethwick, near Birmingham.
F. A. W. SELLEY	Technical Assistant, General Electric Co., Ltd., Kingsway, London, W.C.
G. E. TATE	Mechanical and Electrical Engineer, The "Acme" Lighting and Engineering Co., Waverley Road, St. Albans.

The names of applicants presented at the previous meeting on December 12th were read out again, and these gentlemen were formally declared members of the Society.

The CHAIRMAN (Dr. James Kerr) then called upon Mr. C. E. GREENSLADE and Mr. J. E. S. WHITE to open the discussion on **"The Need for Suitable Training in Illuminating Engineering."** In the ensuing discussion Dr. F. T. CHAPMAN (Board of Education), Mr. A. BLOK, Miss R. E. SQUIRE (Home Office, Factory Dept.), Mr. L. GASTER, Professor FRENCH (Leeds University), Mr. W. A. BISHOP (Croydon Gas Co.), Mr. P. J. WALDRAM, and Mr. S. SKINNER (Principal of the Chelsea Polytechnic) took part. Communications from a number of gentlemen associated with other educational institutions were read, and Mr. L. GASTER presented a summary of the replies received to a list of queries circulated with a view to obtaining information on existing courses in illuminating engineering and prospects of future developments. The replies so far received expressed a sympathetic interest in the subject and welcomed co-operation from the Society.

After a vote of thanks had been passed to the authors the CHAIRMAN announced that the next meeting would be held on Tuesday, February 20th, when a discussion on **"The Projection of Light"** (lanterns, kinema projectors, flood lighting, etc.) would be opened by Mr. W. J. JONES and Mr. E. A. MARX, Junr.

THE NEED FOR SUITABLE TRAINING IN ILLUMINATING ENGINEERING.

Prior to the meeting of the Illuminating Engineering Society on January 16th a circular of inquiry was drawn up and sent to professors at various educational institutions, and accompanied by a letter drawing attention to the discussion. It was pointed out that the practical value of a general knowledge of the various methods of illumination available for use in the home, and in schools, libraries, streets, factories, etc., is now widely recognised. While only a few students are likely to be concerned with the manufacture of lamps and lighting appliances, a knowledge of the best methods of applying them in practice is useful in all professions and vocations, but facilities for obtaining such information are lacking at many educational institutions.

The replies so far received indicate a very sympathetic attitude towards the proposals and a readiness to welcome the co-operation of the Illuminating Engineering Society.

A copy of this tentative list of queries, as circulated, is given below. Any additional information, furnishing an indication of what has been done in the past and what are the future possibilities of progress, would be much appreciated.

To be returned to L. Gaster, Hon. Secretary of the Illuminating Engineering Society, 32, Victoria Street, London, S.W.1.

Name of College or Institute.....

Name of Professor or Member of Staff.....

Date.....

Queries :—	***Remarks.***
(1) Is instruction in Illuminating Engineering included in the regular curriculum ; if so, to which Departments (*i.e.*, engineering, physics, architecture, etc.) are these courses allotted ?	(1)
(2) Are special extra courses of lectures (*e.g.*, evening courses) on Illumination and various aspects of Lighting arranged ? If so, for whom ? Are such lectures delivered by members of the staff or by outside experts ? And are they open to persons who are not students at the College ?	(2)
(3) As a result of discussions and the deliberations of committees of the Illuminating Engineering Society during nearly 14 years much useful information on various aspects of illumination is now available, and the Society has on several occasions been instrumental in arranging courses of lectures on illuminating engineering. In the absence of adequate textbooks on illumination for the use of students, and in view of the desirability of uniform methods of instruction, would you be willing to accept the co-operation of the Society in drawing up a syllabus for suitable courses, to be delivered either by members of your staff or by fully qualified lecturers provided by the Society ?	(3)

N.B.—***A copy of your regular curriculum and also a syllabus of any special courses of instruction on illumination would be much appreciated.***

THE NEED FOR SUITABLE TRAINING IN ILLUMINATING ENGINEERING.

By C. E. GREENSLADE and J. E. S. WHITE.

(Presented at the meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W.C., at 8 p.m., on Tuesday, January 16th, 1923.)

IN opening a discussion on "The need for suitable training in Illuminating Engineering" one's thoughts revert to the admirable inaugural address delivered by the first President of the Illuminating Engineering Society—the late Professor Silvanus P. Thompson. How admirably he would have dealt with the present subject! In his masterly address he mentioned a long series of problems awaiting solution, each initiated by the phrase "Does anybody know. . . ." He emphasised the fact that while few members of the community are producers of light, all are users. He predicted that the initial career of the Society would necessarily be one of self-education; but in the final portion of his address he looked forward to the time when by the publication of papers of standard merit and the holding of useful and fruitful discussions, expert illuminating engineers competent to deal with all phases of the subject would have developed. Meantime he emphasised the primary function of the Society to collect, discuss and disseminate knowledge, and to arouse the public and public bodies to the economic and social importance of the subjects with which the Society deals.

In the subsequent years we have travelled a good distance. We have collected much information and made considerable progress towards the solution of many of the problems which Dr. Thompson propounded. We have found in illumination not only a useful but a most fascinating field of study. We have learned to appreciate more fully the great importance of light as an element in civilisation and in the service of mankind. The question we have now to consider is how this knowledge may best be made accessible both to the expert and the general public.

Education and training in illuminating engineering may be considered from various aspects. Much of the Society's work is already educational. We have held many joint meetings at which different aspects of illumination have been brought to the notice of various sections of the community—school and educational authorities, librarians, medical men, etc. In the future we might well go a step further by arranging for suitable supplementary papers before bodies composed of architects, medical men and engineers of various kinds. Such papers would deal with matters which are familiar to experts in lighting but need to be brought to the notice of those in other professions and trades. The technical press has from the first taken a sympathetic view of the Society's work and devoted a considerable amount of attention to illuminating engineering during recent years, while in the daily press several articles dealing specially with the subject have recently appeared.

In addition to papers dealing with what may be called "vocational" aspects of illumination, popular lectures for the benefit of the general public may be considered. There are surely few subjects that lend themselves better to illustration than illumination, involving as it does an appeal to the eye. There are so many striking applications of light, both visible and invisible, that can be made the subject of attractive experiments and the direct practical bearing of illumination on daily life is so evident.

This leads one to consider what may be termed the first step in the educational ladder, the arrangement of simple lectures at schools. It is of great consequence that the next generation should grow up with a better appreciation of

the benefits of good lighting, so that they will not willingly tolerate dark and ill-lighted homes of their own, and will also be conscious of the need for good illumination in their daily work. Already the teaching of hygiene in the elementary schools is leading to a general standard of health far higher than that usual in the past. Reference was made recently in THE ILLUMINATING ENGINEER to the medical discovery of the part played by light in eliminating the disease of rickets, and we are only beginning to realise how essential is the part played by light in general health. Surely an elementary knowledge of the use of light should be ranked as of equal importance to cleanliness and other factors in hygiene. Such lectures would, of course, be simple and popular in scope and illustrated by attractive pictures showing the effects of bad lighting. It is only necessary to mention the propaganda of the "Safety First" movement in schools to realise how much might be done in this field.

Assuming that a start was made in the elementary schools by arousing an interest in lighting, the next step would be the continuation of the work in secondary schools. Here again one would naturally avoid abstruse technical questions. Occasional lectures on the subject would not be regarded as a burden but rather as a special treat. Boys of the present age are keenly interested in practical applications of science. They could be made to feel that they have themselves opportunities of applying in practice the hints given and they would quickly respond to the efforts of a lecturer who knows how to bring home the romance of recent advances in the production of light, and its application to many new fields. Such topics as aerial lighthouses, the use of invisible light for secret writing and invisible signals, might be used as illustrations in order to kindle interest.

We come next to the treatment of illumination at colleges and polytechnics, where students dealing with phases of science of engineering are working. While lighting is a subject that should naturally find some place in engineering courses, students in other fields, notably architecture and medicine, might also have their attention drawn to the subject by appropriate lectures. The lighting of many important buildings rests largely in the hands of the architect and it would be a great gain if, at the outset of his career, he could acquire a general insight into the best modern methods and if his interest was sufficiently excited to lead him to add to his knowledge year by year. The same applies to the medical profession who, as advisers of the public, could do so much to promote a better appreciation of the value of good lighting in the interests of health.

The exact nature of such courses offers a fruitful field for discussion. Engineering students, besides being instructed in technical matters, should have their attention drawn to the effects of light on the eye, and to the general considerations of shadows and appearance of buildings by artificial light which guide the architect in his choice of systems of lighting. In the courses of the past too much stress has perhaps been laid on the purely technical aspects of lighting, and too little attention paid to the factors that enter into the lighting of public buildings, museums, etc. Similarly, lighting fittings should not be considered purely from the standpoint of efficiency, but such points as the choice of period and their selection to harmonise with the nature of interiors should be studied. The experience of the architect would be helpful in shaping this portion of the course and likewise in suggesting methods of treating natural lighting—a subject which is apt to be overlooked in courses devoted only to the use of artificial illuminants. The chief modern illuminants (not merely electric lamps, but gas, oil and acetylene sources), and the underlying physical principles of light-production should be dealt with and due attention given to shades and reflectors. Measurement of light and illumination should naturally form an important item and should be dealt with on thoroughly modern lines. Colour is another subject that in these days needs special treatment.

The method of arranging this instruction requires discussion. In 1912 special courses of lectures on illumination were arranged in three of the chief technical institutes in London, under the

auspices of the Illuminating Engineering Society, and there have been other special courses since. At educational centres where it is not very easy to graft instruction in illuminating engineering on to the existing syllabus, this mode of dealing with the subject, if necessary by the aid of outside lecturers, presents advantages. But in many cases a certain amount of work on lighting is already included and might be modernised to form a regular part of the curriculum. Teachers in these days are apt to complain of the difficulty of fitting in all the desirable subjects. No doubt this is something of a problem. But in most evening courses four or five weeks towards Christmas time, when the evenings are dark, could be spared—possibly in the second year of the electrical course, though it would also be useful to include some lectures in the first year so that the continuity of work is preserved.

The exact mode of dealing with the problem will naturally depend on local circumstances. In some cases it will probably be found that some of the existing matter might with advantage be omitted to make room for more useful items. For instance, courses on electrical engineering sometimes contain unduly detailed treatment of lamps and lamp-manufacture, to the neglect of applications of light. I should like to make a plea for the consideration of the use of light as a tool, a matter in which everyone is interested, rather than lamp-construction in which relatively few students will be concerned in after-life. Nor should the course be confined to one illuminant. Students in electrical engineering, for example, should have the opportunity of learning what can be done with gas. Courses on electric wiring or gas fitting might often be modified to include more on the arrangement of lights. Attention should be drawn to such fundamental points as the avoidance of glare, both from imperfectly screened sources and from polished surfaces, the amount of illumination for various purposes and its relation to the darkness of material used, and the importance of lights in eliminating troublesome shadows. All such points should be illustrated by practical examples and suitable illustrations. By this time there are doubtless available a considerable number of photographs illustrating good and bad methods of lighting. Would it not be possible for slides to be collected and lent to various teaching institutions for lectures? If in addition agreement could be reached on the chief points to be included in the syllabus this should pave the way for a more uniform method of dealing with the subject.

The chief aim in such a syllabus should be to illustrate principles by practical examples. Some of the methods customary in past years are unsuitable to-day. Measurement of light and illumination is now a relatively simple process. Experiments should not be confined to tedious repetition work on a photometric bench involving laborious calculations. Modern illumination photometers should be used to measure the actual illumination at various points in rooms. The explanation of the spectrum should be followed by simple demonstrations of the bearing of this knowledge on the efficiency of illuminants, and the subject of colour should be illustrated by reference to "artificial daylight." Such simple devices as the cubical box with whitened interior for measuring total flux of light should form part of the photometric equipment.

Whatever form it assumes, instruction in illuminating engineering should find some place in the curriculum of leading technical institutions. At the present time, with a very much fuller knowledge than existed ten years ago, there should be no difficulty in finding lecturers. In cases where the existing staff did not see their way to deal with the subject, courses might be delivered by lecturers recommended by the Illuminating Engineering Society on the lines already followed in the lectures of 1912. As the work expanded it might be possible to arrange for a course for teachers in technical institutions, who, with their groundwork of scientific knowledge, would find little difficulty in subsequently delivering lectures to students.

This leads to another conception, the arrangement of a special third year or post-graduate course at the larger institutions, in which the subject could be dealt with more fully. An indication of the possible lines of such courses is

afforded by the excellent series of lectures, organised by the Illuminating Engineering Society in the United States, at the Johns Hopkins* and Pennsylvania† Universities. Each lecture was delivered by an expert on the subject dealt with and the lectures were subsequently reprinted in book form. Is not the time ripe for a similar effort in this country?

A useful element in such a course, which might occupy a complete session in the third year, would be a suitable textbook for the use of students. At the present time we have nothing really suitable intermediate between the more elaborate works issued and the smaller handbooks that have appeared. In the field of laboratory work, particularly, there is little guidance for a teacher starting a course on illuminating engineering and a small book describing the chief apparatus available and a series of practical experiments would be useful.

The same applies to expedients in lecturing. One's aim should be to impress on the student that he is learning something both practical and interesting. Lectures should be so attractive as to be regarded as one of the most pleasing items in the day's work, not an additional burden! The subject of lighting lends itself particularly well to demonstration and the writer has witnessed some ingenious devices for the purpose of illustrating the inverse square law, the conception of flux of light, and the effects of various types of reflectors. If a little book could be issued in which such devices were collected and illustrated, this would also be a useful aid to the teacher.

Finally we come to what must be regarded as the logical outcome of training, the establishment at leading colleges of illuminating engineering departments. The need for experts on lighting is much better realised than in the past and such steps as the inclusion of a requirement of adequate and suitable lighting in the Factory Acts will doubtless provide additional incentive to take up illuminating engineering as a course of study. It is a matter for consideration whether such a department could be organised at the present time, or whether it should be allowed to grow gradually out of such developments as have already been suggested.

The nature of the syllabus will naturally depend on the time that can be allotted at each institution to illuminating engineering, but the following is given as a rough indication of some of the chief items that should be included.

Syllabus of Lectures.

Fundamental Quantities; and Principles.—Nature of light, reflection, refraction and inverse square law. Candlepower, illumination, brightness, reflecting and absorption coefficients, flux of light.

The Eye and the effect of brilliancy, contrast, glare, etc.; methods of shading.

Shades and Reflectors.—Design of reflectors, prismatic and matt surfaces, direct and indirect lighting, floodlighting, etc., and shadows.

Photometers for measuring light and illumination, polar curves of light distribution, integrating spheres and methods of measuring flux or M.Sph. C.P.

Daylight Illumination.—Design of window-space, measurement of daylight ratio, comparison of natural and artificial lighting.

Methods of Producing Light.—Underlying physical theory. Gas lighting (high and low pressure), electric (glow, arc, vapour, etc.) lamps, acetylene and petrol air gas, etc.

Practical Lighting Problems.—Intensity of illumination for various purposes, choice of lighting units and spacing arrangements, comparison with daylight conditions, artificial daylight, maintenance problems, etc. Effect of colours of walls and ceilings. Illustrations based on lighting of schools, libraries, shops, factories, streets, etc. Problems involved in lighting of public buildings, museums, picture galleries and buildings of architectural distinction.

Laboratory Work.

Setting up an improvised grease-spot photometer, and examination of common types. Use of some form of illumination

* A Series of Lectures delivered at the Johns Hopkins University, Baltimore, U.S.A. (2 vols.) Oct.–Nov., 1910.

† "Illuminating Engineering Practice," a series of 22 lectures delivered at the University of Pennsylvania, U.S.A., 1916.

photometer in order to form a conception of "foot-candles." Study of illumination produced by various arrangements of lamps, and the effect of typical shades and reflectors. Tests with globe photometer (or simple cubical box). Measurement of brightness and coefficients of reflection.

The above suggestions are not in any sense exhaustive and are intended merely to give an idea of the lines on which work might proceed.

In conclusion, the chief points for discussion might be summarised as follows :—

(1) What arrangements are practicable for lectures on illumination in Elementary and Secondary Schools and what should be the nature of the subject matter for such lectures ?

(2) What is the maximum number of weeks that can be devoted to the subject in an evening technical course in say, electrical engineering, bearing in mind competing demands on the time available?

(3) What is the syllabus that can be effectually dealt with in such a time ? And which parts are most essential for, say, the first four weeks ?

(4) Would it be desirable for a standard syllabus to be prepared with the co-operation of the Illuminating Engineering Society ?

(5) What measures should be taken to provide for the co-operation of the medical and architectural professions in connection with courses on illuminating engineering ?

(6) Is the time ripe for a full day course in illuminating engineering at some of our larger Technical Colleges ?

(7) The desirability and feasibility of the provision of expert lecturers by the Society.

(8) The selection of a series of suitable slides for loan to lecturers on illumination.

(9) The preparation of suitable text-books covering the matter dealt with in lectures and describing suitable experiments for laboratory work.

DISCUSSION.

Dr. F. T. CHAPMAN, after thanking the Council for the invitation to take part in the discussion, said that his remarks represented his personal views, and should not be regarded as having any official sanction from the Board of Education.

The problem of providing education in the use of artificial light was an exceedingly important one which had been seriously neglected in the past. He was glad to see that the Society was taking an interest in such education, not only in schools and colleges, but for the benefit of the general public. When a better public appreciation of the importance of good lighting existed, the provision of courses of instruction in illuminating engineering would be justified by the support they would receive.

The education in matters relating to illumination of those who would become consulting, electrical or contracting engineers should prove a fairly straightforward problem. Architects, builders, mining engineers and others were also concerned with lighting, but their requirements were somewhat different and required study. The draft syllabus included in the paper was useful as a basis for discussion. He would like to see included in the third section some specific reference to the design of reflectors, which was a very important matter. It must be remembered that as a rule such a syllabus could not be considered alone, but would have to be co-ordinated with other syllabuses in engineering, pure science and mathematics, and it would have to form a part of courses already in existence. Hence the exact form might have to be modified somewhat according to local circumstances.

In the list of points for discussion at the end of the paper, he noted a reference to the possibility of arranging lectures on illumination in elementary and secondary schools. He thought that the most fruitful way of dealing with this problem would be through the medium of courses for teachers which were arranged by many local education authorities. Such courses might be given by experts, of whom the Society had

many amongst its members. If the subject matter of such a course of lectures could be published as a pamphlet this would be very helpful to teachers in enabling them to build up a suitable syllabus for their own classes.

As regards the maximum number of weeks that could be devoted to illumination in technical institutions, there were two kinds of evening courses, termed "Senior" and "Advanced." The senior course began when the student was about sixteen and lasted three years; the advanced course followed and lasted two years. The senior course was a very full one, and teachers had usually great difficulty in dealing adequately with the whole of the present syllabuses. It would scarcely be possible to introduce a special course on Illuminating Engineering, but it might be possible to displace some of the existing matter, such as the treatment of the manufacture of electric lamps, and thus make room for a few lectures in the third year. In the advanced course students began to specialise, and he thought that in some instances courses might be arranged which would enable perhaps one-third of the time to be given up to Illuminating Engineering. The treatment would, however, be preferably devoted to fundamental principles and facts.

For the reasons explained previously, he did not think that different educational institutions could adhere strictly to a standard course. The syllabus must naturally be left in the hands of the school authorities, but suggestions from the Society might be of great value to teachers in affording guidance to them as to the most important matters to be included. Similarly, he had no doubt that educational authorities would welcome the assistance of the Society in producing a suitable textbook, and it would be a most useful thing if a suitable series of lantern slides could be prepared for loan to schools.

He hardly thought that the moment was ripe to attempt to establish a full day course in Illuminating Engineering at the larger technical colleges. The crucial question was whether or not a man who had taken such a course would find sufficient demand for his services when he left college. It seemed more feasible to consider a post-graduate course for students who had already qualified in a course of a more general character. He thought that in some colleges expert lecturers might be invited to give occasional special lectures of a more or less popular kind, to which persons outside the school or college would be invited, and thus assist the aim of the Society in bringing about a better general appreciation of the importance of the subject.

Mr. ARTHUR BLOK said that so far as those present at the meeting were concerned the authors were surely preaching to the converted, but he agreed that effort was necessary to bring home the importance of the matter to some educational authorities. He firmly believed in the need for disseminating knowledge of illuminating engineering, but data were needed as to what courses existed or would be considered by various institutions, and the series of queries which had been prepared and circulated should yield some useful information on these points. Obviously, the first people to be approached were scholastic bodies. Another section whose co-operation should be sought were gas and electricity supply companies or authorities and the makers of lamps and lighting appliances, and a third class was found in the various trade organisations. It was of primary importance that wiremen and gasfitters should have a knowledge of the elements of good lighting. He thought that if the questionnaire, to which Mr. Gaster would refer later, showed a real demand for education in illuminating engineering, the best procedure might be for the Society to form a Committee, consisting partly of representatives of the Society and partly of representatives of bodies to whom the inquiries were addressed. Such a Committee might do very valuable work either in a creative or an advisory capacity.

It was obvious that the method for developing an interest in good lighting among children must be entirely different from that adopted for adults, and especially those with some technical interest in the subject. Assistance could

be rendered to teachers in schools by preparing the bases of a number of ready-made lectures, but the matter should not be too cut and dried. The Society might make it known that they were ready to help teachers without tying them to the delivery of a particular course, or it might even arrange short summer or similar courses of instruction for teachers. In technical schools and colleges the matter would be simpler, as these institutions usually had courses dealing with gas manufacture and distribution, electrical engineering or physics in which appropriate reference to lighting could be inserted. He had been instrumental in inducing certain educational authorities to consider schemes of this nature, but had found that the question of expense was an increasing difficulty in these days of universal retrenchment.

Wiremen, gasfitters and salesmen were particularly in need of instruction in illumination, and were often unfortunately placed in that their instruction could not be readily linked with a co-ordinated course including the allied subjects such as mathematics. He suggested that educational authorities might approach the local electricity supply or gas undertakings with a view to arranging instruction in accordance with the needs of their employees.

In his own experience of evening courses in electrical engineering he found it possible in the student's third year to devote about three evenings to the principles of illuminating engineering, and another three evenings to practical photometric work. This comprised about twelve to fifteen hours' instruction in illuminating engineering pure and simple, and could be readily developed so as to dovetail into the course on electrical engineering. These remarks applied to the Croydon Polytechnic where they endeavoured to convey some knowledge of the principles of lighting in addition to the usual instruction in respect of the manufacture of lamps and electrical measurements.

Miss R. E. SQUIRE (Home Office) said that, from her experience in industrial areas, a syllabus similar to that suggested by the authors would be extremely valuable. It seems to contain just the material that should be brought before those acting as foremen, welfare supervisors and managers of factories. In introducing the subject of illumination to manufacturers and workers, to whom it was of vital importance, she had often been struck by the strange ignorance of principles of lighting amongst those who were otherwise well educated. If the efforts of the Society led to the establishment of courses in the principles and practice of good illumination in some of the chief industrial areas, this would be of immense benefit. The question of expense had been mentioned, but she thought that in the chief industrial areas there should be no difficulty in getting a large attendance which would go far towards eliminating this difficulty. The preparation of a pamphlet dealing in a simple way with the chief principles of good lighting, and the preparation of suitable lantern slides as illustrations, would be useful as a guide to teachers. Inspectors of factories, who had themselves to be fully informed on the subject in its industrial aspects, should also be able to benefit from the Society's educational activities.

Mr. L. GASTER (Hon. Secretary) recalled that the Society had taken an active interest in education in Illuminating Engineering from its inception. As far back as 1912 he had approached the London County Council on the subject, with the result that courses were given at three educational institutions in London, including a set of 12 lectures, given by various experts who were members of the Society, at the Regent Street Polytechnic. These and other institutions had since arranged courses on their own account at intervals. At the time when these lectures were initiated there were not many lecturers available, and few books on illuminating engineering. The position is now greatly improved, as much information has been collected and crystallised at meetings of the Society.

In order to ascertain the present position they had circulated, prior to the meeting, a list of queries (see p. 34) to a number of professors at leading colleges and institutions. The replies so far received indicated that there was a general recognition of the need for

instruction in illuminating engineering, and a most sympathetic attitude towards the offer of co-operation by the Society.

He had listened with pleasure and interest to the remarks of Miss Squire, who had every opportunity of knowing from her experience the need for instruction in proper methods of industrial lighting. In this field the work of the Home Office Departmental Committee on Lighting in Factories and Workshops had been a most potent educational influence, and in future it should become so to an even greater extent. The Society had already expressed its desire to make known in every way possible the conclusions arrived at by this Committee, and there should also be opportunities for useful work in enabling inspectors to gain an adequate knowledge of illuminating engineering and methods of measurement. Allusion had been made in the paper to the educational propaganda of the London "Safety First" Council in the schools, a striking feature being the prizes awarded for an essay competition in which 35,000 pupils took part, in the first year, but as many as 144,000 later. Attempts, on similar lines, to bring before the notice of the young people the value of good lighting should be encouraged, for the importance of creating such impressions at an early age could scarcely be overestimated.

Some remarks had been made in the discussion regarding the cost of providing special courses on lighting, but the subject is of such national importance and permanent benefit, that reasonable expenditure should not be grudged.

In conclusion Mr. Gaster said that he heartily concurred in the suggestion that the Society should form a small Joint Committee to study the whole question of education in illuminating engineering, with the co-operation of educational authorities. The discussion had revealed a general recognition of the need for such education. All that was needed was to provide the requisite machinery for its introduction. The issue of a suitable textbook should also receive attention.

He had much appreciated the valuable remarks of Dr. Chapman, of the Board of Education, and his assurance of his personal support in this matter. In an educational campaign of this nature it was essential to obtain the sympathetic co-operation of teachers, and in this connection the suggestion that occasional addresses should be given to teachers was welcome.

He proposed to deal with the subject editorially in the issue of the journal containing the discussion.

Professor FRENCH (Leeds University) said that illumination was of enormous importance in daily life; quite apart from its value in relation to work it was an important factor in the enjoyment of leisure. When one considered the important bearing of illumination on public safety and the efficiency of industrial concerns, one was amazed at the ignorance of the public on the subject. This ignorance was not only found with the lay public; it was also sometimes met with in professional men. The lighting of provincial towns and factories was sometimes determined by men who had only rudimentary ideas on the subject, and it was evident that there was a definite need for the illuminating engineer.

As regards the education of the illuminating engineer, he wished to speak on conditions in colleges and institutions. In the electrical department of the University of Leeds the instruction in illuminating engineering was necessarily brief; but it comprised as much as could be incorporated in a heavily burdened course, for the students took in so much and no more. The lectures were limited to ten, supplemented by a short laboratory course. He was also trying to introduce tests of street lighting with the co-operation of the Corporation of Leeds. This scheme was in course of development. The introduction of suitable training for the complete illuminating engineer was largely a question of finance. Given the necessary money, there were two possible courses: the first of these was to try and incorporate illuminating engineering into a university course. In order to do this it would be necessary to convince the university authorities that illuminating engineering was a sufficiently important scientific subject to be incor-

porated as a final or honours subject; he personally thought it was. The course would be very roughly as follows: for the first and second years, as an ordinary engineering student, a man would receive instruction in intermediate subjects such as mathematics, a good grounding in physics, drawing, chemistry, mechanics, machine designs, theory of engines, and theory of electrical machines and appliances. In the third year, provided the university had accepted the subject as a final or honours one, the student would specialise in illuminating engineering and allied subjects. Such a third year course might include gas engineering and an advanced course in physics and in the higher theory of electricity including the electron theory, which might form the basis of researches into the sources of light of the future. There was room for investigations in this field. He thought that in future one should aim at utilising other principles than those on which our present high temperature sources of light were based. There were many other subjects which should be included in the field of study of the illuminating engineer.

An alternative course would be for the Illuminating Engineering Society to establish an educational institution of their own. This should be not only for teaching, but what was equally important—possibly even more so—research. The advantage of this second course was that it gave concentration. The lack of concentration was a great fault in the technical teaching in England. There were three universities almost within thirty miles of Leeds. If instead of these there had been originally one great university, what an excellent staff of specialists could have been got together, and how magnificently equipped the laboratories might have been if all the money spent on these various universities could have been concentrated on one! In the same way he would advocate a concentration on illuminating engineering; first in one institution—then as the need for the services of illuminating engineers developed, in other institutions distributed over the country.

Mr. S. SKINNER (Principal of the Chelsea Polytechnic) said that there could be no question of the desirability of general knowledge of correct methods of illumination. But he agreed with previous speakers in thinking that in general the treatment of the subject in a college or institution would have to be co-ordinated with other subjects. It had been justly contended that lighting was as important as heating and ventilation; and he thought that these three subjects should be treated together. It would be of great benefit to the public to have the services of men able to deal with these three matters, which played such an important part in their comfort. Another point that emphasised this view was that in practice one had often to make a compromise between two of these factors; for instance, in designing windows to allow ample access of daylight one had to remember that the chilling effect of these glass surfaces had to be compensated by special heating arrangements. In addition the complete illuminating engineer should have some knowledge of physiology and modern physics, and, perhaps, also a knowledge of psychology.

Mr. P. J. WALDRAM pointed out that architects formed a body of men who had a great deal to do with lighting, and it was most desirable that some treatment of illumination should be embodied in courses for students entering this profession. Stress had been laid on the importance of educating the general public, but in general they accepted what was provided. The manufacturer might also be educated, but it was quite usual for him to leave the lighting of his works mainly in the architect's hands. Speaking as an architect he believed that a knowledge of illumination to architects was of the very greatest importance.

THE CHAIRMAN (Dr. James Kerr), in closing the discussion, remarked that there was a great future for illuminating engineering, which was constantly extending in new directions. As an instance he might mention the recent discoveries that had been made in regard to the beneficial effect of sunlight on the human body. In the discussion they had considered the possibilities of

education both in colleges and in elementary schools. The former question had been dealt with in some detail by Professor French and it was interesting to hear his experience at Leeds University. The importance of conveying an impression of the value of good lighting to children was great, but the introduction of such teaching in elementary schools was somewhat difficult owing to the time being so completely allotted to various subjects; however, some simple instruction in the use of light might replace something less directly useful.

The whole subject of illuminating engineering was new. It was mainly the growth of the last twelve years. But a demand for good lighting had been created and should continue to increase. No doubt the Council would consider the suggestion of appointing a joint standing committee consisting of members of the Society and representatives of educational bodies to consider this question of education in detail.

Professor E. W. MARCHANT, Liverpool University (*communicated*):—I am sorry that I shall be unable to attend the meeting to discuss suitable training in illuminating engineering. We have arranged courses of lectures in connection with our ordinary work dealing with this subject. These lectures cover the general question of the illumination necessary for different purposes and the methods available to obtain it. They also describe the various types of incandescent lamps that are used and the methods of testing their candlepower and efficiency. We also deal with the measurement of illumination by means of the various forms of illumination-photometers available to-day.

On the other hand we have not any demand, at present, for specialised illuminating engineering education. There is some scope for expert advisers on illumination, but as a rule this work will have to be done by men who deal with other things as well. A course of lectures was delivered some time ago on Electric Illumination, but we have not had a course of this kind for some time.

Professor W. C. CRAMP, Birmingham University (*communicated*):—I am sorry that it was not possible for me to be present in London for the discussion, but as Head of the Department of Electrical Engineering here, I should appreciate very much anything that could be done to improve the present training that is given in illuminating engineering; and consequently I should be very willing to accept the co-operation of your Society in drawing up a syllabus for a suitable course. In their ordinary fourth year course the Electrical Engineering students have only time for the usual photometric tests, and unless steps were taken to divide the course—which is against the general policy of this University—I think that the special training to which you refer would have to be relegated to a post-graduate period.

If the representatives of manufacturing firms requiring assistants for illuminating engineering work would be willing to recognise the value of such a post-graduate course, I would support the idea of such specialised training before the Faculty of Science, and I feel certain that this would be sufficient for such a course to be started. At present my experience of placing many students is that the demand for men having this bias is very small. This I believe to be due to the fact that insufficient propaganda work has been done among those responsible for lighting schemes, and also to a desire on the part of directors to avoid expenditure which they regard as unproductive. If the demand can be increased we will train the men and shall be glad of your help; that, I think, summarises the situation.

Dr. L. C. MARTIN (Dept. of Tech. Optics, Imperial College of Science and Technology) (*communicated*):—I regret that I am prevented from being present at the discussion on the need for suitable training in illuminating engineering, but I have read with much interest the paper by Messrs. Greenslade and White.

During the past year I have acquired some little experience by giving to some of the advanced students in the Optical Engineering Department of the Imperial College, and to about six other persons, a short course of six evening lectures on

Photometry and Illumination. The lectures were fairly well advertised beforehand, and I am wondering whether the number of the students attending is a reflection on the lack of demand for such a course, or on other factors.

I do not think, as things are at present, that the authors' ideas of the instruction on illumination to be given in schools will quickly be realised, *unless* such instruction could be given by special visiting teachers, as an occasional treat. Where are the special teachers to be found? The average secondary science teacher has trouble enough to accomplish a little good work on standard lines, and before such special instruction becomes at all possible the present slipshod treatment of "Photometry" and the total neglect of "Illumination"—characteristic of the usual Physics course in the universities—will have to be radically changed. This last point, it seems to me, is one which does merit the serious immediate attention of the Society.

The ideal to which I look forward is this: there should be in or near London a central technical college for highly specialised courses in pure and applied science, including such varied departments as are found at the Imperial College at the present time. This college would confine itself to post-graduate courses which would extend over, say, one or two years. The students attending such courses would be such as had already passed satisfactorily through ordinary science courses at other colleges, and would thus be ready to profit by specialisation. This would mean the extension of the total period of college training at least to four years, but that will sooner or later be found inevitable in any case. I suggest that the subject of Illuminating Engineering, might very well have such an advanced department devoted to it. The main activities of such a department would be: (1) Full time instruction to a few specialist students; (2) original research by the staff; (3) a limited number of popular lectures open to non-specialist students, medical men, architects and others.

When I look at question number six at the end of the paper "Is the time ripe for a full day course?" I can only reply "No. It is highly *unripe*, at least from the financial point of view." Specialist departments are extremely costly in respect to the number of students trained, and they need a considerable period of growth before they gain the confidence of all concerned and make their results apparent. The more immediate practical need is to improve the efficiency of organisations already in existence, to look especially to the improvement of science teaching in the schools, and to the revision of the Physics courses of the universities.

I imagine that, should there be evidence of a demand, the Society could not do better than bring students requiring such instruction into touch with those university departments where photometry, etc., is already being taught. There would not be much difficulty in meeting any need of extra lectures. Nevertheless, the desirability of the founding and co-ordination of such a specialist department in a central institution is one which should be kept steadily in mind.

Professor J. W. WHITAKER, University College, Nottingham (*communicated*):—In response to the invitation of your secretary, Mr. L. Gaster, I wish to draw attention to the needs of the coal mining industry in the matter under discussion.

The subject of lighting in mines has occupied the attention of many of the most distinguished scientists and mining engineers since the time of Davy and Buddle. The man in the street recognises at once that the handicap above all others with which the miner is saddled is the fact that he is shut off from the sun's light in the hours of his work; and, though familiarity with the artificial and comparatively poor illumination in the mine may render the miner somewhat indifferent to the unnatural conditions, the prevalence of nystagmus, the number of accidents and the general inefficiency resulting from inadequate lighting underground must be admitted by all. In recent years a certain amount of attention has been given to improving the candlepower of the miner's lamp, but the fact that its average horizontal candlepower (to say nothing of the average spherical candlepower) is well below 1·0, and sometimes below 0·5

gives some idea of the scope still remaining for development.

The enormous cost of nystagmus to the coal industry and to the nation has been pointed out by Mr. Llewellyn and others, and there is now little doubt that the chief cause of the disease is insufficient illumination. Improvements in the lighting of the mine have been attempted by (1) improving the candlepower of the flame lamp; (2) substituting electric hand lamps for flame lamps; (3) substituting electric cap lamps; but there is still much to be done. Everyone who has had experience of work or travelling in a mine is familiar with the pleasant relief to the eyes which is felt where parts of the mine have been whitewashed, such as main junctions of the haulage roads, the pit bottom, etc. Roads which have been stone-dusted with ordinary shale dust (of dull grey colour) are much pleasanter to travel than roads where the coal-dust has not been so treated. If the stone-dust employed (to render the coal-dust non-explosive) be white—such as precipitated calcium carbonate from water softening plant, Chance's Mud and the like—the improvement in effective illumination is most remarkable. The regulations of the Coal Mines Act do not require that workings in the immediate vicinity of the coal-face be stone-dusted; but, if a white stone-dust be employed in the roads, there is every advantage to be gained by using it also at the face, not only to prevent the danger of a coal-dust explosion, but also to reduce the tendency towards nystagmus. The enormous importance of the reflective power or reflection ratio of the strata and dusts in the mine has not been overrated by Dr. Elworthy.

Before such elementary facts as the above can be properly understood, however, it is essential that the fundamental and derived units of lighting should be clearly defined and thoroughly grasped; and if the subject is to receive the attention which it deserves from mining men, the methods of measuring candlepower and illumination must be studied both in the laboratory and in the mine. The assistance of the medical profession is of course essential in combating nystagmus, but an enormous amount of useful work may be done by the mine managers and others engaged in the industry by an intelligent application of the principles of Illuminating Engineering. The lighting of mines is still in the early stages of development. If the consideration and skill which has been bestowed on making the miner's lamp safe had been also devoted to improving the candlepower and the general illumination at the coal-face, etc., lighting conditions in the mine to-day would have been far different. Considerable experience and knowledge are now at the service of all interested in these matters, thanks largely to the work of the Illuminating Engineering Society and a few pioneers; but before this store of knowledge can be usefully drawn upon, training and education in the principles of the subject is essential.

I think it highly desirable that all mining students should have, in addition to the ordinary work on the construction and upkeep of safety lamps, a thorough grounding in (1) the fundamental and derived units of illumination, etc.; (2) the methods of photometry; (3) the importance of diffused reflection; and (4) the general nature and causes of nystagmus. Further, the mine manager now has so many duties to perform—and duties of a widely varying nature—that there is ample room for the expert in mine-illumination. In this respect it is interesting to note that in the recent report of the Miners Safety Lamp Committee, it is recommended that the men in charge of safety lamps at mines should qualify for the position by examination. This examination, it is hoped, will eventually include in its syllabus the points mentioned above.

In the meantime anyone who by his efforts is able to improve the lighting conditions in the coal mines of to-day will merit the gratitude not only of those who are compelled to work at the face, but of all employed in the industry. Illuminating engineers are surely most required in the dark places, and perhaps I may be forgiven for twisting the excellent Japanese proverb when I say "The darkest place is not under the candle; it is under the earth."

Mr. W. A. BISHOP: The authors have taken a broad view of the subject and I am in general agreement with their suggestions. In training in illuminating engineering, I would urge that due regard should be paid to all forms of artificial illuminants; but the main question is the study of illumination rather than the light-yielding agents.

Education in the "use and abuse of light" needs consideration from two points of view—the creation of a desire for scientific illumination and the provision of qualified experts to give effect to this desire. The first condition has been keenly studied by the Society for many years. It is chiefly with the second point that I propose to deal. The suggestion that the co-operation of educational authorities should be sought is valuable. In view of the attention already devoted to physics and mathematics in existing courses the principles underlying scientific illumination should be readily assimilated, if presented in an elementary manner. Students who are keen on illumination should be able to attend extension courses at neighbouring polytechnics and technical institutions. At present the elements of illuminating engineering are apt to be crammed into general schemes of study such as gas supply or electrical engineering, with the result that the student gets only a confused smattering of knowledge.

Speaking from the "gas" standpoint, I am sure that there is much to be done in educating gas supply students in illumination, especially from the *practical* standpoint. Among the points that should be associated with the study of gas-piping are: (1) the intensity of illumination to be provided for various purposes, (2) the layout of lighting units, heights, distances apart, etc., and (3) the use of reflectors, diffusing media, etc. Such points as these are of great importance to the student concerned with applications of gas for lighting. It is a pity that illuminating engineering does not receive more consideration in such courses of study, and I, personally, should welcome the framing of definite courses of study, preferably independent of either electrical engineering or gas supply, whereby young men in the ranks of the gas industry may equip themselves to fulfil the role of a practical lighting expert. I fully endorse Mr. Blok's remarks regarding the requirements of the wireman and the gasfitter. Laboratory work is very necessary, but for the gasfitter a practical knowledge of installation work, of the correct positions of lights and the resultant conditions of illumination is even more important. Intelligent workmen are a valuable asset and should be given every assistance in obtaining information on illumination. In my personal experience many such men are keenly desirous of learning about illumination, —but where are the facilities? Much research has been expended on securing increases in the commercial efficiency of gas lighting during recent years, for example in designing more efficient and attractive lighting fittings, automatic lighters, etc.; but the actual work of installing gas lighting systems needs to be better understood.

Any scheme which will help forward educational matters in this direction will, I am sure, be appreciated in gas circles, as at the moment there seems to be a wave of enthusiasm pervading the industry. Therefore illuminating engineering should receive the loyal support of gas supply undertakings—a matter which my Chief (Mr. Sandeman) strongly urged in a paper read before the Society in December, 1921.

In conclusion I would like to add a few words in regard to the value of educational work in schools, both elementary and secondary. A short time ago the British Commercial Gas Association published an interesting booklet entitled "Gas Notes for Teachers," dealing with the manufacture, distribution and utilisation of gas. Gas supply undertakings purchased large numbers of these books and distributed them amongst headmasters and mistresses of schools in their respective areas. In my own district (Croydon) these books were greatly appreciated by teachers, and I believe that good use has been made of this publication.

Mr. A. E. GASTER (*communicated*) :— With regard to the meeting of the Illuminating Engineering Society on January 16th, I would like to add one or two remarks from the technical student's standpoint. The necessity of interesting university authorities in the question of illumination, so that their co-operation should be obtained, was firmly urged; but at the same time the great importance of interesting the *Students* should not be overlooked. To my mind, the best way of doing this is to bring home to them the existence of the Illuminating Engineering Society and urge them to attend one or two meetings. Usually, the Student attends the meetings and lectures of a Technical Institute, and more often than not comes away, if not less wise, at least no wiser than before. But in the case of the meetings and papers of this Society, much of the matter is given in a more popular form, and an idea of the broadness and scope of illuminating engineering may be well obtained from one or two of the meetings.

Personally, about seven years ago, I read a paper on Illumination before the School Scientific Society, my keenness and interest being stimulated solely by attending a few meetings of this Society. Is the formation of a Student's Section desirable and practicable ?

Messrs. GREENSLADE and WHITE (in reply) :—

The course of the discussion has revealed a general agreement that improvement in training is needed. The proposed syllabus has been strengthened by including designs of reflectors as suggested by Dr. Chapman.

Dr. Martin points out that courses on light usually given in Physics might be brought up to date with great advantage to all concerned, and Dr. Cramp advocates educational work among architects and the public as a necessity in order to create a demand for better lighting, and the services of the illuminating engineer, when trained. Encouragement also comes from Dr. Kerr and Prof. Whitaker, who suggest fresh fields of activity for illuminating engineering.

In section (2) from a minimum of six to a maximum of ten weeks' instruction spread over courses has been suggested, and the contributions of those speakers and contributors who have stated what is being done in various institutions are very useful. Under heading (4), the provision of assistance in the shape of a suggested outline syllabus from the Society was very generally welcomed.

A post-graduate course is generally agreed to be the best *immediate* method, either run by the colleges, a special college, or by the Society, but in any case involving the assistance of the Society. Dr. Chapman, Prof. Cramp, Dr. Martin and Prof. French all suggest this course.

Mr. A. E. Gaster's suggestion of a students' section would also prove a distinct help in this direction.

A standing committee is suggested by Mr. Blok as the best means of dealing with sections 4, 6 and 7, and the suggestion that lantern slides should be hired to lecturers is welcomed.

The authors are pleased to find their plea for the importance of light as a tool, rather than consideration solely of light-giving sources, so ably backed up by Mr. Bishop.

They have to thank Mr. Ryeland for the loan and exhibition of his complete portable daylight projection apparatus, at somewhat short notice, for displaying some of the slides.

This apparatus, though intended primarily for an advertising sign, might prove of great assistance in educational effort. The cabinet contains a projection apparatus with a metal filament lamp that can be connected to an ordinary electric lamp circuit as a source of light. The slides could be changed by pressing a button, while the end of the cabinet carries the special screen on which a brilliant three-foot picture is thrown. Being self-contained, and always in adjustment, it could be wheeled from room to room as required, and would enable slides to be shown as illustrations with the minimum amount of preliminary preparations, even in a sunny room and without the trouble of darkening the room. This would produce that " appeal to the eye " so desirable but sometimes so troublesome to obtain.

LIGHTING CONDITIONS IN MINES.

In view of the recent researches of the National Institute of Industrial Psychology, illustrating the relation between lighting conditions and output in mines, it is of interest to observe that this matter was recently the subject of comment in the House of Commons. Mr. Barker (Labour Member for Abertillery) moved a resolution calling for legislation to secure the fullest protection for miners, and contended that in order to reduce accidents the lighting should be improved. He recalled that the Miners Lamp Committee's report advocated the use of a sufficient number of flame safety lamps to be used by competent workmen to make examinations at reasonable intervals during the shift. On grounds of economy, as well as humanity, it would pay companies to improve lighting in collieries.

Mr. J. A. Spencer (Labour Member for Broxstowe, Notts) quoted the report of the Miners Nystagmus Committee to the effect that deficient illumination was the essential factor in causing miners' nystagmus; the only step required to prevent the disease was the introduction of a lamp of sufficient candlepower to give men reasonable light in which to perform their task.

Lt.-Col. Lane-Fox (Secretary for Mines) agreed that nystagmus was increasing. Anything that could be done to produce a better lamp would be welcome. But it was no good saying that there must be better illumination until a suitable lamp was available; meantime every effort was being made to improve lamps, and the Research Board was engaged in constant study of the problem.

Mr. Spencer, interposing, quoted a case in which the introduction of electric lamps at Nottingham had lead to a decrease in nystagmus from 0·38 per cent. to 0·9 per cent.

Lt.-Col. Lane-Fox said that he was well aware of the improvement effected by the introduction of electric lamps, and he was glad to think that they were being more and more installed in collieries. But when they had got a complete installation of electric lamps the question of protection against gas arose. He hoped that some genius would devise a lamp which would not only yield greater light but would afford protection against gas.

THE POSTAGE OF SCIENTIFIC PERIODICALS.

Reference has frequently been made in this Journal to the claims of scientific societies for a revision of postal rates, seeing that the existing charges for monthly scientific periodicals are unduly heavy. The question was recently raised in the House of Commons when Lt.-Col. Howard-Bury asked the Postmaster-General whether steps could not be taken to register the journals of a scientific society, published monthly, as newspapers, in view of the small cost that would be entailed?

Major Barnston, replying on behalf of the Postmaster-General, said that the newspaper rate of postage was confined by statute to journals published at intervals of not more than seven days. He could not undertake to promote legislation extending the rate to monthly newspapers. Such an extension could not be confined to the variety of journals referred to, and would involve a considerable sacrifice of revenue on a post which has always been carried on at a loss.

NATIONAL ILLUMINATION COMMITTEE OF GREAT BRITAIN.

(*Affiliated to the International Commission on Illumination.*)

Constituted by the co-operation of:—
THE ILLUMINATING ENGINEERING SOCIETY.
THE INSTITUTION OF ELECTRICAL ENGINEERS.
THE INSTITUTION OF GAS ENGINEERS.
THE NATIONAL PHYSICAL LABORATORY.

Representatives nominated to serve on the Committee for the year 1923:—

H. BUCKLEY (a)
W. J. A. BUTTERFIELD (c)
J. G. CLARK (c)
W. C. CLINTON (b)
HAROLD G. COLMAN (c)
KENELM EDGCUMBE (b)
LEON GASTER (a)
PERCY GOOD (b)
F. W. GOODENOUGH (c)
HAYDN T. HARRISON (b)
JAMES KERR (a)
J. T. MACGREGOR-MORRIS (b)
CLIFFORD C. PATERSON (a)
SIR JOSEPH E. PETAVEL (d)
A. P. TROTTER (a)
J. W. T. WALSH (d)
ROBERT WATSON (c)

(a) Nominated by the Illuminating Engineering Society.
(b) Nominated by the Institution of Electrical Engineers.
(c) Nominated by the Institution of Gas Engineers.
(d) Nominated by the National Physical Laboratory.

The Committee has made the following appointments:—

Representatives of Great Britain on the Executive Committee of the International Commission on Illumination:—

LEON GASTER and ROBERT WATSON.

OFFICERS:

Chairman: KENELM EDGCUMBE.

Vice-Chairmen: CLIFFORD C. PATERSON and ROBERT WATSON.

Treasurer: W. J. A. BUTTERFIELD, 66, Victoria Street, London, S.W.1.

Secretary: H. BUCKLEY, National Physical Laboratory, Teddington, Middlesex.

NATIONAL ILLUMINATION COMMITTEE OF GREAT BRITAIN.

Report of the Chairman for the Year 1922.

In February last the provisional Definitions of Photometric Terms and Units proposed by the British National Committee were published together with a prefatory note and have been officially adopted by the three constituent Societies. They also form the basis of a set of Photometric Definitions shortly to be issued by the British Engineering Standards Association as part of a comprehensive set of Electrical Engineering terms.

The Definitions in question, whilst agreeing with the decisions of the International Commission on Illumination held in Paris in 1921, go considerably further and are in some respects at variance with a set of Definitions approved in July, 1922, by the American Engineering Standards Committee. The occasion of a visit by Dr. Clayton Sharp to this country in December last was seized upon to discuss these Definitions with one so largely instrumental in the drafting of the American Definitions. Dr. Sharp kindly consented to attend a Meeting of the Nomenclature Sub-Committee, and as a result of this interchange of views, the Sub-Committee are now considering how the proposed Definitions can be amended so as to minimise the points of difference between this country and the United States.

A preliminary list of Symbols has also been prepared by the Nomenclature Sub-Committee and, after submission to the British Committee, these have been communicated to a number of interested Societies, publication being deferred until their criticisms, if any, have been considered.

Dr. Mailloux (U.S.A.) and Mr. K. Edgcumbe (Gt. Britain) were asked by the central office of the National Illumination Commission to prepare an English translation of the French official text of Terms and Definitions adopted in Paris in 1921. A Meeting was held in this country and the translation agreed upon. The text forms an Appendix to this Report.

At the 1921 Paris Meeting of the Commission an International Committee on Automobile Headlights was appointed and Mr. K. Edgcumbe was subsequently nominated by the British National Committee as their Representative thereon. A fairly complete set of recommendations having been drawn up in the United States by a Committee under the Chairmanship of Dr. Clayton Sharp, the subject was discussed with that gentleman on the occasion of his visit to this country, and at a subsequent interview with Mr. Perrin of the Ministry of Transport the question was raised of how the British National Committee could best serve the interests of this country in connection with Automobile Headlights. It appeared that the most useful course would be to appoint a Sub-Committee to consider the recommendations which had already been published in other countries, with a view, if possible, of arriving at common agreement through the medium of the International Headlights Committee.

In view of the fact that a large and increasing part of the work of the British National Committee relates to standardisation, it was decided, with the approval of the three constituent Societies, to ask the British Engineering Standards Association to form a sectional Committee on Illumination to which such matters could be referred. It is proposed that this Committee should deal solely with standardisation or similar questions referred to it by the British National Committee, all international matters being dealt with by the National Committee as heretofore.

K. EDGCUMBE.
Chairman.

January, 1923.

PHOTOMETRIC DEFINITIONS.

Official Translation of the French Text.

Luminous Flux.—Is the rate of passage of radiant energy evaluated by reference to the luminous sensation produced by it.

Although luminous flux should be regarded, strictly, as the rate of passage of radiant energy as just defined, it can, nevertheless, be accepted as an entity for the purposes of practical photometry, since the velocity may be regarded as being constant under those conditions.

The Unit of Luminous Flux is the Lumen.—It is equal to the flux emitted in unit solid angle by a uniform point source of one international candle.

Illumination.—The illumination at a point of a surface is the density of the luminous flux at that point, or the quotient of the flux by the area of the surface when the latter is uniformly illuminated.

The Practical Unit of Illumination is the Lux.—It is the illumination of a surface one square meter in area, receiving a uniformly distributed flux of one lumen, or the illumination produced at the surface of a sphere having a radius of one meter by a uniform point source of one international candle situated at its centre.

In view of certain recognised usages, illumination may also be expressed in terms of the following units:—

Taking the centimetre as the unit of length, the unit of illumination is the lumen per square centimetre; it is known as the "Phot." Taking the foot as the unit of length, the unit of illumination is the lumen per square foot; it is known as the "Foot-Candle."

1 Foot-Candle = 10·764 Lux.
= 1·0764 milli-phot.

Luminous Intensity.—(Candlepower). The luminous intensity (candlepower) of a point source in any direction is the luminous flux per unit solid angle emitted by that source in that direction. (The flux emanating from a source whose dimensions are negligible in comparison with the distance from which it is observed may be considered as coming from a point.)

The Unit of Luminous Intensity (Candlepower) is the International Candle, such as resulted from agreements effected between the three National Standardising Laboratories of France, Great Britain and the United States, in 1909.*

This unit has been maintained since then by means of incandescent electric lamps in these laboratories which continue to be entrusted with its maintenance.

* These Laboratories are: the Laboratoire Central d'Electricité in Paris; the National Physical Laboratory in Teddington, and the Bureau of Standards in Washington.

TOPICAL AND INDUSTRIAL SECTION.

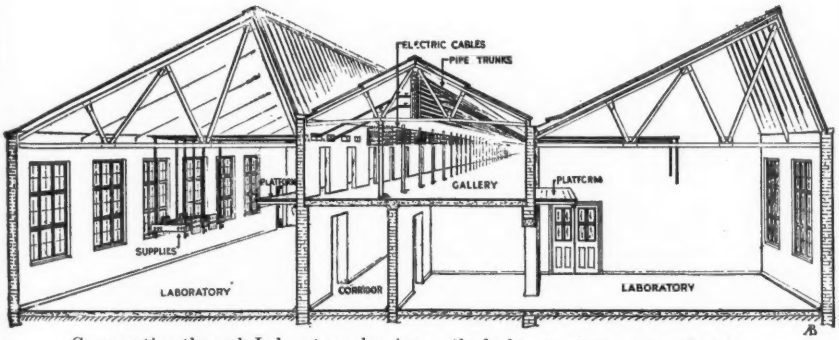
[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

THE RESEARCH LABORATORIES OF THE GENERAL ELECTRIC CO., LTD.

A visit of the Press to the Research Laboratories of the General Electric Co., Ltd., at Wembley, took place on Monday, February 26th, prior to the official opening on the following day. The general design of the building is illustrated in the accompanying cross section, and the equipment is on thoroughly modern and up-to-date lines. The building has a frontage of 400 feet and a total floor area of 80,000 square feet, occupying an enclosure of four acres. A feature of special interest is the arrangement of the various services—water, gas, hydrogen, vacuum, compressed air, etc., the cables and trunk pipes being carried along a gallery running the length of the building, and then brought down from the ceiling to the various rooms, in the manner shown in the illustration of the lamp laboratory-factory on page 54.

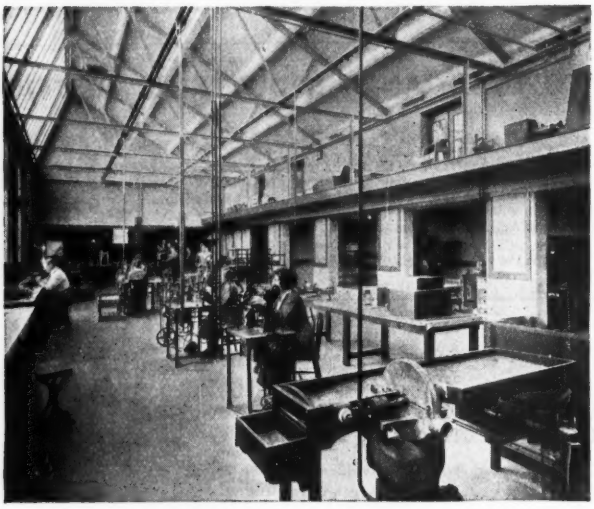
This method of running pipes and mains has the great advantage that it is unnecessary to interfere with the floors, which, in nearly all the rooms, are of concrete covered with Marbello jointless flooring.



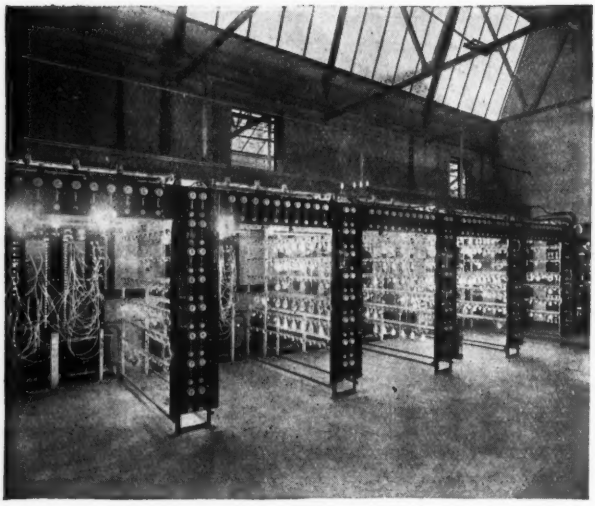
Cross section through Laboratory showing method of conveying mains and piping.

In order to prevent any confusion the pipes conveying gas, water, etc., are painted in distinctive colours. The space under the central gallery to the right of the corridor is used for small rooms such as photographic dark rooms, store rooms, etc., thus overcoming one of the chief drawbacks to the north light arrangement,

(*Continued on page* 56)



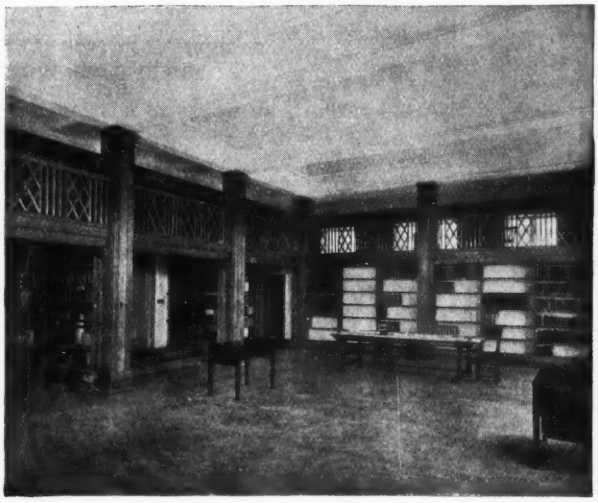
The Lamp Laboratory-Factory.



Routine Testing of Lamps.

The Research Laboratories of the General Electric Co., Ltd.

INDEX, February, 1923.



The Library.

The Research Laboratories of the General Electric Co., Ltd.

i.e., the difficulty of obtaining certain small subsidiary areas wanted for special purposes.

The arrangements for supplying electricity are of special interest, power being supplied from a central sub-station in the building. In view of the varied experimental requirements, both d.c. and alternating (single and 3-phase) at different voltages, capable of exact regulation, are provided, and there is also a battery room for supplying a steady voltage for lamp work.

Visitors were afforded an opportunity of making a complete tour of the building. It is impossible to describe in detail the many interesting experiments that were in progress. The building is devoted mainly to work on lamps and valves used for wireless work. There are well-equipped wood and metal workshops, in which we noted a specially long photometric bench and a large rectangular box for measurements of flux of light, in course of construction. Photometric work with an Ulbricht sphere was also in progress. The arrangements for life-tests are exceptionally complete, the arrangements for tapping off transformers enabling the voltage to be varied to any extent.

Perhaps the most interesting feature is the combination, with the laboratories, of a small lamp factory where any special designs can be tested and made on a small scale, so that any difficulties in manufacture can be detected and overcome before mass production at the Company's main factories is attempted. All the usual processes of a lamp factory, including the preparation of tungsten from the ore and the subsequent drawing out of wire, were in operation, and special rooms are devoted to microscopic tests of the structure of filaments.

In one of the rooms there was an interesting exhibit of the new neon lamps, including a pleasing demonstration of a new and simple method of obtaining an idea of the wave-form of an alternating supply. This apparatus consists merely of a series of neon tubes mounted radially on a disc which is rotated. The length of the luminous discharge in the tube is approximately proportional to the instantaneous voltage; accordingly, when the disc is revolved one sees the wave-form traced out as a series of luminous patches.

The library, shown on page 55, is well equipped and organised, and a regular system of abstraction and tabulation of any scientific papers likely to be of interest has been devised.

Following the inspection of the laboratories the visitors were entertained to luncheon, when Mr. C. Wilson (Managing Director, Osram G.E.C. Lamp Works) and Mr. C. C. Paterson (Director of the Laboratories) explained the steps which had led to the building and equipment of the laboratories and the objects which it is intended to serve. At the opening ceremony, on the following day, addresses were delivered by the Right Hon. Lord Robert Cecil and Sir Joseph Thomson, O.M., F.R.S., both of whom referred to the great importance of research in industry and congratulated the Company on the very well-equipped laboratories which they now possessed.

A NEW ELECTRIC LAMP FOR MICROSCOPE WORK.

A new electric lamp for microscope work constructed by Messrs. Ogilvy and Co. has some special features. An obscured electric lamp is used, but is so arranged that there is no interference with the image by a projected granular luminous surface. The size of the luminous source can be adjusted by shutters, and there is a special holder permitting the use of colour-filters of any size.

ROYAL SANITARY INSTITUTE.

The Right Hon. T. R. Ferens, P.C., J.P., High Steward of Hull, has consented to accept the Office of President of the Thirty-fourth Congress of the Royal Sanitary Institute, to be held in Hull from July 30th to August 4th, 1923.